

For the Columbia River in Scenario 1, the existing conditions with dams in place, the mean annual frequency of temperature excursions above 20 deg C remains close to 0. between Grand Coulee Dam (Columbia River Mile 596.6) and Priest Rapids Dam (Columbia River Mile 397.1). The influence of the warmer Snake River leads to an increase of the average frequency of excursions at McNary Dam (Columbia River Mile 292.0) of 0.07. Downstream from McNary Dam, the mean frequency of temperature excursions continues to increase to 0.14 at Bonneville Dam. The range of the frequency of excursions for the simulated average plus one standard deviation and the simulated average minus one standard deviation is of the order of  $\pm 0.03$  deg C.

For the unimpounded case (Scenario 2), the mean annual frequency of excursions is approximately 0.08 at Bonneville Dam. The estimated uncertainty of the frequency increases slightly compared to the results of Scenario 1, so that the range of frequency of temperature excursions associated with one standard deviation is approximately  $\pm 0.04$  deg C. The increase in the uncertainty of the estimate for the river in the unimpounded scenario is due to the change in system dynamics associated with shallower depths and higher velocities. In a qualitative sense, these differences are significant; that is, the unimpounded Columbia River has significantly fewer temperature excursions than does the impounded river.

The frequency properties of Scenario 3, for which tributary temperatures are constrained to be always less than 16 °C, are similar to Scenario 1 on the Columbia River upstream of its confluence with the Snake. The combined average annual flows of advected sources in this segment (Table 3-1) are less than 10 percent of average annual flow of the Columbia River at Grand Coulee Dam. The impact of these sources on the thermal energy budget of the main stem Columbia is, therefore, small. The 16 °C constraint was not applied to the Snake River, however, reductions in tributary temperatures in the Snake, particularly the Salmon and Clearwater rivers, results in a slightly lower mean frequency of excursion at Bonneville for Scenario 2 compared to Scenario 1. The effect of impoundments at Bonneville remains qualitatively significant greater for Scenarios 1 and 3 when compared to the unimpounded river (Scenario 2).